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Comparative study of two diagnostic methods, ultrasound and Magnetic Resonance Imaging in measurement of the angle and depth of trochlear groove

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ABSTRACT

Introduction: This study evaluates the efficacy of ultrasound versus magnetic resonance imaging (MRI) for measuring the angle and depth of the trochlear groove in knee evaluations at Al-Zahra and Kashani hospitals. *Material and Methods:* It is an observational cross-sectional study among patients referred for knee MRIs at Al-Zahra and Kashani hospitals over two years, from January 2021 to December 2022. The study population comprised 70 patients, which was calculated to achieve an 80% power and a 95% confidence interval. The selection was via convenience sampling. For each patient, a radiologist performed and reviewed knee MRIs to measure the trochlear angle and depth. These measurements were compared to those obtained using ultrasound under similar conditions, ensuring methodological consistency. *Results:* Trochlear groove measurements were analyzed for depth and angle using ultrasound and MRI across various demographics, including gender, age, and body mass index, revealing no statistically significant differences (P>0.05). Ultrasound demonstrated sensitivities of 81.43% for angle and 78.57% for depth measurements, while MRI exhibited specificities of 93.10% for angle and 91.07% for depth. Comparative analysis showed minor mean differences between the two methods: 0.83 ± 1.01 mm for depth and 1.01 ± 3.38 degrees for angle. *Conclusion:* Both diagnostic methods proved effective and comparable in measuring the trochlear groove's dimensions, suggesting suitability for clinical use. Given the closely aligned results, further research with expanded sample sizes may enhance the understanding of these methods' diagnostic capacities in orthopedic settings.

Keywords: Ultrasound Imaging, Magnetic Resonance Imaging, Angle, Depth, Trochlear Groove.

1. INTRODUCTION

Patellar instability is a common abnormality in children and young people, which is the cause of most knee problems at this age (Hasler and Studer, 2017). The rate of primary dislocation of the patella is 6 people per 100,000 people, the highest rate of which occurs between the ages of 10 and 17 with an incidence of 21 people per 100,000 people (Sillanpää et al., 2008; Fithian et al., 2004). Almost half of the patients experience patellar dislocations again after the first dislocation and its maintenance treatment (Hawkins et al., 1986). Predisposing factors of patellar instability include trochlear dysplasia, patella alta, and excessive distance between the tibial tubercle and trochlear groove (Berruto et al., 2013). Recognizing and measuring these anatomical anomalies shows the dislocation mechanism specific to each person and can significantly help the surgeon choose the appropriate treatment method (Diederichs et al., 2010).

Trochlear dysplasia, as the most common predisposing factor for patellar instability, is seen in 96% of patients with patellar dislocation (Dejour et al., 1994). On the other hand, considering that in knee flexion of more than 30 degrees, the role of soft tissue in the stability of the patella is minimized. Therefore, the morphology of the trochlear femur plays a very significant role in creating a stable position for the patella. Trochlear dysplasia, characterized by deviations in the morphology and depth of the trochlear groove, stands recognized as a significant predisposing element contributing to patellar dislocation. Although the diagnosis of this predisposing factor can play a crucial role in the prevention of dislocation and choosing the appropriate treatment, its diagnosis, especially its types, is still a challenge (Dong et al., 2018).

The trochlear groove usually is concave, and its lateral wall is longer than its medial wall, which allows the patella to move down the center of the distal femur slowly and without difficulty. When the trochlear groove is not deep enough or is flat or even convex, it is known as trochlear dysplasia. In this situation, the patella does not have the necessary bone tension to maintain stability, and the patella will rely on the medial patellofemoral ligament and the quadriceps muscle to keep itself in the appropriate anatomical location (Dejour and Saggin, 2010). In the studies that have been done until today, it shows different results. Several investigations have indicated that magnetic resonance imaging (MRI) may serve as a viable substitute for both ultrasound and computed tomography (CT) imaging modalities.

In some studies, the sensitivity and specificity of MRI and CT scan ultrasound have been reported (Dupuy et al., 1997; Jibri et al., 2019; Zhang et al., 2015; Schoettle et al., 2006; Tscholl et al., 2017). Diagnosing the predisposing factors of patellar instability and dislocation is particularly important in prevention and choosing the proper treatment method. Among the diagnostic modalities of trochlear dysplasia, MRI is the modality of choice, but with limited access and high cost. Furthermore, subjecting the patient to ionizing radiation, CT scan also has low accuracy in differentiating the different tissues of the knee, and lateral radiology alone is not enough to diagnose trochlear dysplasia. According to scientific theories, ultrasound during knee flexion can check the depth and angle of the trochlear groove.

This method has more advantages than modalities that use ionizing radiation, such as CT scans and lateral radiography. Among these advantages is the ability to distinguish different tissues and not expose the patients to ionizing radiation, which is considered an essential feature since the patients are in their growing age (Razek et al., 2009; Fatemi et al., 2010). For these reasons, ultrasound theoretically can measure the trochlear angle and depth of the trochlear groove, it is more accessible and inexpensive than other modalities, and it also does not expose the patient to ionizing radiation. Drawing from the examination of existing studies, no research has been designed and implemented in the field of comparison of ultrasound findings with MRI as a modality for the diagnosis of trochlear dysplasia. Therefore, this study was conducted to compare the two diagnostic methods of ultrasound and MRI in measuring the angle and depth of the trochlear groove in patients referred for knee MRI to Alzahra and Kashani hospitals.

2. MATERIAL AND METHOD

Study population

The current cross-sectional descriptive investigation was carried out among a cohort of patients referred for knee MRI examinations to the radiology departments of Al-Zahra and Kashani hospitals from Jan 2021 to Dec 2022. The sample size in this study was calculated according to the formula with 80% power and 95% confidence coefficient of 70 people who were included in the study using

convenience sampling. The inclusion criteria in this study included only referring to the radiology departments of Al-Zahra and Kashani hospitals from Jan 2021 to Dec 2022.

The exclusion criteria of this study included previous surgery on the knee joint, soft tissue lesions, and bone lesions in this area. In addition, patients who underwent MRI imaging showed severe bone degenerative changes in the patellofemoral joint, as well as patients who were not able to position them for an ultrasound due to excessive effusion of the joint or any other technical problem such as a wound in the area where, led to the inability to perform ultrasound, they were excluded from the study. The information related to the exit criteria was extracted through interviews and examination of the medical history of the patients. Patients' demographic information including gender, age, body mass index (BMI), and MRI indication was obtained.

Data Collection

In this study, according to the request, knee MRI was taken from the patients, and trochlear angle and trochlear groove depth were measured and recorded in MRI by a radiologist. The method of measuring trochlear groove depth in MRI was as follows: In the axial section of the fat-saturated T2-weighted sequence, a tangent reference line was delineated along the posterior aspect of the femoral condyles. Then three lines perpendicular to the reference line include line A, from the anterior surface to the posterior surface of the femur's lateral condyle, equivalent to its maximum anterior-posterior diameter; line C, from the anterior surface to the posterior surface of the femoral medial condyle, comparable to its maximum anterior-posterior diameter, and line B: It was drawn from the deepest point of the trochlear sulcus to the reference line.

After that, the trochlear groove depth was calculated according to the formula ((A + C/2) - B). Also, the trochlear angle was calculated in MRI in the axial section of the fat-saturated T2-weighted sequence by measuring the anterior angle between the medial and lateral femoral condyles. Then the patients were subjected to knee ultrasound and these measurements were calculated and recorded by another radiologist unthinkingly in the ultrasound. The ultrasound technique was such that the patient lay supine on the bed so that the knee was flexed at a 90-degree angle. Using the Aixplorer Ultimate (Supersonic) surface probe, the trochlear angle and depth of the trochlear groove were measured at the highest visible surface of the knee joint cartilage in the axial section and perpendicular to the distal femoral bone.

The trochlear angle was calculated by measuring the angle formed between the deepest point in the depth of the trochlear groove and the most anterior surface of the articular cartilage of the medial and lateral femoral condyles. Also, the depth of the trochlear groove was measured by drawing a tangent line on the most anterior surface of the articular cartilage of the medial and lateral femoral condyles and calculating its distance to the deepest point of the trochlear groove under the same conditions. Finally, the measurements taken in the two modalities were compared. To avoid observer bias, all ultrasounds were performed by a radiologist.

Ethical considerations

Ethical clearance for this study was obtained from the Ethics Committee of Isfahan University of Medical Sciences, Iran, under the protocol number IR.MUI.MED.REC.1400.573. All patients were explained about the method and objectives of the study and the confidentiality of all information.

Data analysis

Finally, the collected data was entered into SPSS software (Chicago, IBM, IL, version 20). Numerical data were characterized using measures of central tendency, specifically the mean and standard deviation. Quantitative variables between the two groups were compared using an Independent T-test, while qualitative variables were assessed for differences between the groups using a Chi-Square statistical test. Additional statistical analyses, including analysis of variance, were employed as appropriate, with statistical significance set at a threshold of $P < 0.05$.

3. RESULTS

This study was conducted among 70 patients referred for knee MRI. The mean and standard deviation of the age of the patients was 34.48±12.87 years. Of these 70 people, 25 were men (35.7%) and 45 were women (64.3%). In this study, body mass index, age group, average trochlear angle, and average trochlear depth were investigated, which are reported in (Table 1). In this study, the depth and

angle of the trochlear groove in the knees of patients were investigated using two methods of ultrasound and MRI based on gender, age group, and body mass, and no significant difference was observed (P>0.05). The results of this study are reported in (Table 2).

Table 1 Background patient information of patients participating in the study

Variables	N	Minimum	Maximum	Mean	Std. Deviation
Age	70	15.00	67.00	34.4857	12.87
BMI	70	20.00	29.00	24.4714	1.75
Sono Angle	70	135.00	148.00	140.8286	3.09
Sono Deep	70	2.00	5.00	3.8900	0.67
MRI Angle	70	138.00	151.00	141.8429	2.96
MRI Deep	70	2.10	5.80	3.9671	0.80

Table 2 Comparison of ultrasound and MRI indices based on background variables

Variables	Depth				Angle			
Method	Sonography		MRI		Sonography		MRI	
Index	Mean ± SD	P-value	Mean ± SD	P-value	Mean ± SD	P-value	Mean ± SD	P-value
Gender								
Male	4.06±0.70	0.108	4.20±0.73	0.062	141.92±3.72	0.064	142.96±3.80	0.075
Female	3.79±0.64		3.83±0.81		140.22±2.53		141.22±2.19	
BMI								
< 25 kg/m2	3.86±0.70	0.587	3.86±0.81	0.104	140.64±3.06	0.424	141.78±3.03	0.584
> 25 kg/m2	3.96±0.61		4.21±0.75		141.30±3.21		142.00±2.86	
Age group								
15-30 years	4.06±0.50	0.054	4.30±0.61	0.063	140.47±2.29	0.256	141.90±3.23	0.303
31-45 years	3.71±0.80		3.62±0.90		142.10±3.39		142.42±3.13	
4-50 years	4.16±0.60		4.13±0.59		140.35±2.81		140.57±2.70	
51-70 years	3.54±0.32		4.00±0.84		137.71±1.97		141.85±0.89	

Based on the objectives of this study, the specificity, sensitivity, and accuracy of the ultrasound method in determining trochlear depth and angle were investigated. Based on the results, the sensitivity of this method in determining the angle was 81.43. Also, the sensitivity of this method in determining the depth is 78.57. In addition, the specificity of this method was 93.10 for determining the angle and 91.07 for determining the depth. Other information is reported in (Table 3 and Figure 1). Based on the findings of this research, the amount of depth difference based on the comparison of the sonography method with MRI was 0.83±1.01, and the amount of angle difference based on the comparison of the sonography method with MRI was 1.01±3.38.

Table 3 Examining the specificity and sensitivity of ultrasound and MRI

Variables	True Positive	False Positive	True Negative	False Negative	Positive predictive value	Negative predictive value	Specificity	Sensitivity
sono_ang_nn	3	4	54	9	42.86	85.71	93.10	81.43

sono_dep_nn	4	5	51	10	44.44	83.61	91.07	78.57

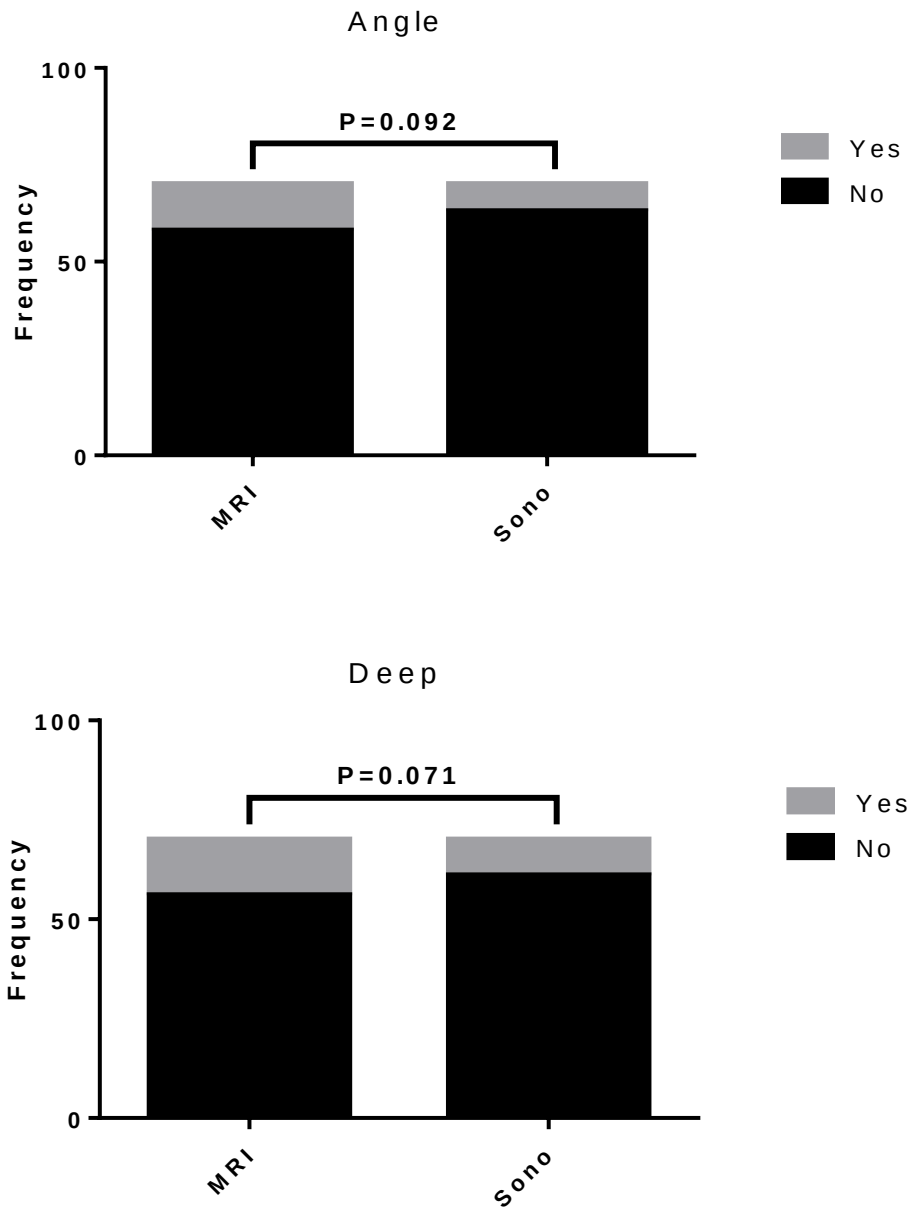

Figure 1 Examining the specificity and sensitivity of ultrasound and MRI methods

4. DISCUSSION

This study compared the two diagnostic methods of ultrasound and MRI in measuring the angle and depth of the trochlear groove in patients referred for knee MRI to Alzahra and Kashani hospitals. In this study, the depth and angle of the trochlear groove in the knees of patients were investigated using two methods of ultrasound and MRI based on gender, age group, and body mass, and no significant difference was observed (P>0.05). Based on the objectives of this study, the specificity and sensitivity of two ultrasound methods in determining trochlear depth and angle were investigated. The amount of angle difference based on comparing the sonography method with MRI was 0.83±1.01, and the amount of depth difference based on the comparison of the sonography method with MRI was 1.01±3.38.

To date, several studies have been conducted in this field. Dejour and Le Coultre divided trochlear dysplasia into four categories. This division is based on crossing sign, sulcus angle (less than or more than 145 degrees), supra-trochlear bump, double contour, and cliff pattern (Dejour et al., 1994). So far, these signs have been found based on lateral radiography, CT scan, or MRI. In CT scans, ionizing radiation is used. The contrast between cartilage, tendon, ligament, muscles, and internal structures is not shown well, and as a result, it is a little difficult to understand them (Dupuy et al., 1997). Therefore, MRI is the standard modality for evaluating patellar dislocation and its predisposing factors. In MRI examination, trochlear sulcus with a depth of less than 3 mm is known as trochlear dysplasia (Jibri et al., 2019).

A study was conducted in 2015 on 97 patients with medial patellofemoral ligament injury. The results of this study showed that the sensitivity, specificity, and accuracy of high-frequency ultrasound in diagnosing the relative tear of this ligament are 90.8, 96.3, and 94.6%, respectively. The same values in MRI examination are 81.6, 95.7 and 91.3% respectively. Also, the sensitivity, specificity, and accuracy of high-frequency ultrasound in detecting complete rupture of this ligament are 86.3, 96.3, and 94%. In this regard, the mentioned values for MRI are 80.4, 95.7, and 92.1%, respectively, which indicates the equal diagnostic value of both modalities in examining injuries of this ligament (Zhang et al., 2015). A study was conducted to evaluate the validity of MRI compared to CT scan in measuring the tibial tuberosity and trochlear groove (TTTG) distance. The results showed that MRI is a powerful modality in determining TTTG and can replace CT scans in its investigation (Schoettle et al., 2006).

A study was conducted on 228 patients with frequent patellar dislocation. The results showed that the findings of lateral radiography related to trochlear dysplasia have only partial agreement in comparison with MRI. For the accurate examination of trochlear dysplasia, the distal end of the femur should be studied in axial sequences (Tscholl et al., 2017). Patellar instability is a common abnormality in young adult age people. Measuring these anatomical anomalies can help the surgeon choose the appropriate treatment method. Trochlear dysplasia, which means abnormal shape and depth of the trochlear groove, is known as one of the predisposing factors in patella dislocation. Although the diagnosis of this predisposing factor can play an essential role in the prevention of dislocation and choosing the appropriate treatment, its diagnosis, especially its types, is still a challenge. So far, trochlear dysplasia has been diagnosed based on a CT scan or MRI. In CT scans, ionizing radiation is used.

The contrast between cartilage, tendon, ligament, muscles, and internal structures is not shown well, and as a result, there is a disturbance in their understanding (Dupuy et al., 1997). Therefore, MRI is the standard modality for evaluating patellar dislocation and its predisposing factors. Ultrasound can be an effective and valuable modality for diagnosing trochlear dysplasia due to its cheapness and availability, as well as the lack of ionizing radiation. The results of other studies show that both MRI and ultrasound methods have relatively high specificity and sensitivity for diagnosis. The data of this study also show that both methods have high reliability for diagnosis. The limitation of this study was the small number of patient samples.

5. CONCLUSION

The results of this study lead to the conclusion that both MRI and ultrasound methods are very effective in measuring the angle and depth of the trochlear groove. Future research endeavors are recommended to incorporate larger sample sizes for more robust conclusions.

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None.

Author Contributions

Dr Mehdi Karami, Dr Samira Soleimany, Dr Maryam Riahinezhad, and Dr Amir Yousefi contributed equally to the conception, design, and execution of this research. All authors read and approved the final manuscript.

Ethical Approval

This study was approved by the ethics committee of Isfahan University of Medical Sciences, Iran, with the code of ethics of IR.MUI.MED.REC.1400.573. All patients were explained about the method and objectives of the study and the confidentiality of all information.

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Conflict of interest
The authors declare that there is no conflict of interests.

Data and materials availability
All data sets collected during this study are available upon reasonable request from the corresponding author.

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